State of California
The Resources Agency
Department of Water Resources

MATRIX OF LIFE HISTORY AND HABITAT REQUIREMENTS FOR FEATHER RIVER FISH SPECIES SP-F3.2 TASK 2 SP-F21 TASK 1

STRIPED BASS

Oroville Facilities Relicensing
FERC Project No. 2100

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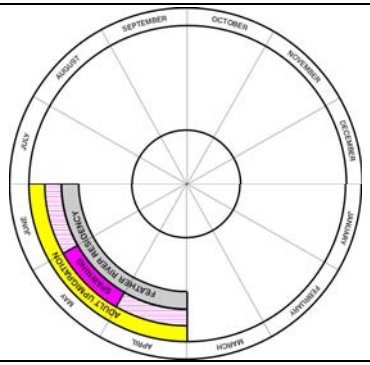
Element	Element Descriptor	General	Feather River Specific
General			
common name (s)	English name (usually used by fishers and laypeople).	Striped Bass, Striper Rockfish, an inappropriate common name widely used on the East Coast (Moyle 2002).	
scientific name (s)	Latin name (referenced in scientific publications).	The scientific name of striped bass is *Morone saxatilis* (Moyle 2002).	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Striped Bass belong to the *Moronidae* family (Moyle 2002).	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	Striped bass are native to the Atlantic coast from the St. Lawrence River to the St. Johns River in Florida. They are also native to the Gulf of Mexico from Florida to Louisiana. Striped bass are distributed widely in the ocean along the Atlantic and Gulf coasts of North America (Moyle 2002). Following the introduction of striped bass into the San Francisco Estuary in 1879, striped bass have reportedly been found in salt water from 25 miles south of the Mexican border to southern British Columbia (Moyle 2002). The main breeding population of striped bass is reportedly in the San Francisco Estuary with a smaller	

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		population in Coos Bay, Oregon. In the Central Valley, striped bass are reportedly found upstream as far as Folsom Dam on the American River, Daguerre Point Dam on the Yuba River, and Red Bluff Diversion Dam on the Sacramento River. A landlocked population of striped bass exists in Millerton Reservoir and San Luis Reservoir (Merced County). Southern California reservoirs fed by the California aqueduct also support striped bass. Striped bass are also found in the lower Colorado River as a result of transplanting from the San Francisco Estuary from 1959-1964 (Moyle 2002). Striped bass have been raised in hatcheries and planted in various California reservoirs, mainly in rivers flowing into the Central Valley (Moyle 2002).	
native or introduced	If introduced, indicate timing, location, and methods.	Striped bass were first introduced to the Pacific coast in 1879 from New Jersey and were planted in the San Francisco Estuary. An additional stocking took place in 1882. This was a successful introduction and by 1888, sport and commercial fisheries for striped bass had started (Moyle 2002).	
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST =State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD =	Striped bass are not listed.	

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	Federally proposed (Delisting); the date of listing; or N = not listed.		
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	Striped bass are considered widespread and stable. Striped bass is one of the most abundant fish in the San Francisco Estuary and are widespread along the Pacific coast. The species, however, is reportedly much less abundant than it was during the first 75 years following its introduction (Moyle 2002).	
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.	The striped bass fishery is one of the most valuable sport fisheries in California (concentrated in the San Francisco Bay and in the Delta), both in terms of the recreation and sport it provides, and also in terms of the economic wealth it generates (Skinner 1962). A commercial fishery for striped bass reportedly existed until 1935 (Kohlhorst 1999). Striped bass are an important sport fish in southern Oregon; highly sought because of the species' fighting ability, large size, easy accessibility, and excellent taste (Emmett et al. 1991).	
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.	Striped bass have a water temperature tolerance that is more similar to warmwater than coldwater species (Moyle 2002).	
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.	As observed in various estuaries along the West Coast, striped bass juveniles, subadults, and adults are pelagic, but somewhat bottom-oriented (Emmett et al. 1991). Striped bass are anadromous, meaning they move regularly between salt and fresh water, and they usually	

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		spend much of their life cycle in estuaries (Moyle 2002).	
bottom or water column distribution	Environment: bottom (benthic) or along water column.		
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.		
Adults			
life span	Approximate maximum age obtained.	Fish over 10 years old and 33.46 inches (85 cm) are reportedly uncommon, but in the 1920s and 1930s, 16- to 20-year-old striped bass were recorded that measured nearly 43.3-47.2 inches (110-120 cm) FL (Moyle 2002). While the species is difficult to age, the maximum age seems to be in excess of 30 years (Moyle 2002). Age at maturity for females is 4-6 years, for males 2-3 years (Moyle 2002).	
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can attain.	In the San Francisco Estuary, striped bass reportedly reach 3.5-4.3 inches (9-11 cm) fork length in the first year, 9.1-11.8 inches (23-30 cm) FL in the second year, 11-16.9 inches (28-43 cm) FL in the third year, and 17.3-21.3 inches (44-54 cm) FL in the fourth year, growing approximately 1.9-3.9 inches (5-10 cm) per year after four years (Moyle 2002). As observed in the middle-Atlantic waters, males mature at about 11.8 inches (30 cm) TL (age 2 or 3 years) and females mature at about 19.7 inches (50 cm) TL (age 4 or 5 years) (Hill et al. 1989). Male striped bass first spawn at 9.8 inches (25 cm) FL and females first spawn at 17.7 inches (45 cm) FL (Moyle 2002). In California, striped bass will reputedly reach approximately 49.2 inches (125 cm) FL [90.4 lbs (41 kg)], and striped bass measuring 70.9 inches (180 cm) FL	

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		[123.5 lbs (56 kg)] have been recorded from the Atlantic coast (Moyle 2002).	
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.	The California state angling record for striped bass is 67.5 lbs (30.6 kg) taken from O'Neill Forebay (Merced County) in 1992 (Moyle 2002). Historic accounts suggest striped bass can weigh 66.1-125.7 lbs (30 – 57 kg) (SWRI 2002). Striped bass weight reportedly ranges from 1.5 – 80 lbs (0.7-36.3 kg), with an average weight of 8 lbs (3.6 kg) (Bell 1991).	
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.	Striped bass have a streamlined body (deepest below the gap between 2 dorsal fins). Their dorsal fin has sharply separated spiny- and soft-rayed portions and their tail is pointed at the tips and slightly forked. Striped bass have a terminal and large mouth, but the maxilla does not reach past the hind margin of the eye (Moyle 2002).	
coloration	Indicate color, and color changes, if any, during reproduction phase.	Striped bass have a silvery-white body with black horizontal stripes (Moyle 2002).	
other physical adult descriptors	Unique physical features for easy identification.	Striped bass can be distinguished by the presence of a small gill on the underside of each gill cover, separation of the spiny- and soft-rayed portions of the dorsal fin, a complete lateral line, and 1-2 spines on the operculum (Moyle 2002).	
adult food base	Indicate primary diet components.	Striped bass will eat any fish, but their principal prey is reportedly juvenile striped bass (Moyle 2002). Within Lake Texoma, striped bass reportedly ate mostly copepods and chironomids and many fish eggs (Matthews et al. 1992). Striped bass are opportunistic feeders and almost any fish or invertebrate found in their environment sooner or later appears in their diet depending on time and place.	

Element	Element Descriptor	General	Feather River Specific
		As a result, diet varies according to species composition in the environment. In the Sacramento River, striped bass prey on juvenile salmon. In the American River, striped bass prey on crayfish and various native fishes. In Suisun Marsh, striped bass prey on threespine sticklebacks. Adult striped bass in the Delta eat threadfin shad and smaller striped bass, while ocean dwelling striped bass eat a wide variety of pelagic fishes (e.g. anchovies and herring) and bay shrimp (Moyle 2002). In Florida waters, the diet of striped bass was dominated by threadfin shad, clupeids, and nymphs of burrowing mayflies (Hill et al. 1989).	
adult feeding habits	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	Striped bass are gregarious pelagic predators (Moyle 2002). Striped bass are opportunistic feeders; almost any fish or invertebrate found in their environment sooner or later appears in their diet depending on time and place (Moyle 2002). A study of stomach contents of the fish within the Delta showed that the diet consisted of small striped bass and threadfin shad (Stevens 1966). In Suisun Marsh, striped bass reside near screened diversions, feeding on small fish, especially salmon, that concentrate near them (Moyle 2002). Striped bass prey on fish entering the fish rescue facility in Clifton Court Forebay and on fish that are trucked back to the Delta after being salvaged (Moyle 2002). Striped bass are reported to not feed continuously, but gorge themselves and then wait until digestion is complete. Feeding is most intense from spawning (spring) through October (Emmett et al. 1991).	
adult in-ocean	For anadromous species,	Ocean residence time for adult striped bass varies, but is	

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residence time	age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.	usually less than 1 year. (Bell 1991).	
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.		
Adult upstream migration (immigration)			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.	General movement of adult striped bass out of bays into fresh water occurs in the fall, with many striped bass wintering in the Delta. After wintering in the Delta, striped bass move back into saltwater in spring following the upstream spawning migration (Moyle 2002). Striped bass reportedly begin to enter the Carquinez Strait from the bay in August, with entry into the Carquinez Strait peaking in October. Angling is excellent from October-November in the Delta and as far north as the Feather River. Potential spawners move into freshwater to spawn in March or April (Skinner 1962). Annual upstream migration into freshwater reportedly occurs in April-June for spawning (Bell 1991). Migration within the Roanoke River, in North Carolina reportedly begins in mid- to late-April (Carmichael et al. 1998). Recovery of tagged fish showed that striped bass move upstream into San Pablo Bay and Carquinez Strait in the fall, then into the Delta in the winter, spread out and ascend tributary rivers in the spring, and move down to the Bay again by early summer (Skinner 1962).	

Element	Element Descriptor	General	Feather River Specific
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.		
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Adult striped bass reportedly can survive water temperatures as high as 93°F (34°C) for short periods of time, although they are under stress once water temperatures exceed 77°F (25°C). Water temperatures over 86°F (30°C) are usually lethal (Moyle 2002). Adults are reportedly capable of surviving abrupt water temperature changes [to water temperatures up to 80.6°F (27°C)] that are simultaneous with shifts from seawater to fresh water (Moyle 2002).	
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	Migration within the Roanoke River reportedly began in mid- to late-April when water temperatures within the lower river reached 62.6°F-64.4°F (17°C-18°C) (Carmichael et al. 1998).	
Adult holding (freshwater residence)			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Adult striped bass can survive water temperatures as high as 93°F (34°C) for short periods of time, although they are under stress once water temperatures exceed 77°F (25°C). Water temperatures over 86°F (30°C) are usually lethal (Moyle 2002). Adults can withstand temperatures of 95°F (35º C) and they can tolerate water temperatures ranging from 32°F – 89.6°F (0º - 32º C) (Emmett et al. 1991). Water temperature for striped bass ranges from 45°F – 80.6°F (7.2º C - 27º C) (Hassler 1988). The reported upper lethal limit for water temperature for striped bass is 90º F (32.2°C) (Bell 1991). In small Tennessee lakes, 3-year-old striped bass water	

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		temperature tolerance reportedly ranged from 21-24°C (Coutant 1977).	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	Striped bass reportedly prefer water temperatures ranging from 68°F –75.2°F (20º - 24º C) (Emmett et al. 1991). Reportedly, no spawning will occur until water temperatures reach at least 57.2ºF (14ºC). Reported optimum water temperatures for spawning appear to be 59°F -68°F (15º -20ºC), and spawning will cease above 69.8°F (21ºC) (Moyle 2002). In small Tennessee lakes, the reported water temperature preference for 3-year-old striped bass was 72ºF (22°C) (Coutant 1977).	
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	Water depth utilized by adults reportedly ranged from 10 feet to 75 feet (3.05-22.9m) (Stevens 1966).	
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	Water depth utilized by adults reportedly averaged 30 feet to 40 feet (9.1-12.2 m) (Stevens 1966).	
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Observations in various estuaries along the West Coast suggest that adult striped bass are found over various substrates, such as sandy beaches, rocky shores, and mussel beds (Emmett et al. 1991).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.	Water velocity range for adults was reported as 0-16.4 ft/s (0-5 m/s) by a habitat suitability index model developed by Hassler (1988). (Hassler 1988).	
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.	Water velocity preference for adults was reported to be 0-3.3 ft/s (0-1 m/s) by a habitat suitability index model (Hassler 1988).	
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	Striped bass move regularly between salt and fresh water and usually spend much of their life cycle within estuaries. (Moyle 2002). In the Saint Lawrence River and estuary, striped bass	

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		reportedly frequented shoreline coves and small streams (Rulifson and Dadswell 1995).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.	Catches in the Sacramento River during late-April and early- May indicate that most males had migrated upstream by that time. Catches of both sexes were low from early-June to early- July. By August, very few striped bass were caught (Stevens 1966).	
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.	The heaviest concentration of striped bass males in the Santa Clara Shoal area of the San Joaquin River occurred in late- May and early-June (Stevens 1966).	
Spawning			
fecundity	Average or range in the number of eggs females lay in a spawning season.	In the Sacramento-San Joaquin Estuary, four-year-old striped bass spawning for the first time had an average fecundity of 243,000 eggs/female, while females of 8 or more years had an average fecundity of 1.4 million eggs/female. Maximum fecundity was 5 million eggs per female (Moyle 2002; Stevens et al. 1985). For a 9-lb (4.1 kg) striped bass, fecundity was reported as 900,000 eggs/female (Bell 1991). The reported average number of eggs per female striped bass within the Saint John River is 313,600 at age 5; 72,427 at age 6; 825,504 at age 7; 7,742,976 at age 9; 9,526,848 at age 11; and 1,064,320 at age 14 (Rulifson and Dadswell 1995).	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.		
nest size	Size and average dimensions of the nest.		
spawning process	Indicate whether nest builder, broadcast spawner, or other.	Striped bass are broadcast spawners. In the Sacramento River, thousands of large striped bass reportedly aggregate close to banks just off the main current. Groups of 5-30 striped bass, composed of	

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		males surrounding one or two females, break away from the main group of fish and swim out into the main river, remaining close to the surface. Individual striped bass frequently turn on their sides and splash vigorously at the surface of the water (Moyle 2002). Observations of striped bass spawning in the San Francisco Bay area suggest that large group(s) gather at the surface and begin to roll over on their sides at a 45º angle. Then they splash their caudal fins. This continues for several hours (Skinner 1962). Striped bass are broadcast spawners. Eggs are released into the water column and fertilized by males (SWRI 2002). Fertilization must occur within one hour after the egg leaves the female (Emmett et al. 1991). Spawning usually peaks in late afternoon and early evening as observed in a variety of estuaries along the west coast (Emmett et al. 1991).	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g. mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Striped bass reportedly appear to have little preference for spawning substrate (Wang 1986). Striped bass reportedly spawn in areas with high flow and/or tidal action which provides increased agitation and aeration to the eggs and helps keep them in suspension (Wang 1986).	
preferred spawning substrate	Indicate preferred spawning substrate (e.g. mud, sand, gravel, boulders, plant bed, etc).	Observations in the Annapolis River suggest that striped bass spawning occurs over substrates that are mainly sand, interspersed between basalt and granite boulders (Rulifson and Dadswell 1995).	
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	No spawning will reportedly occur under 57.2°F (14º C), and spawning will stop over 69.8°F (21º C) (Moyle 2002). In California, observed spawning occurred at water	

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		temperatures ranging from 53.6°F-71.6°F (12º - 22º C) (SWRI 2002). A review of various studies was conducted and the reported tolerance range for spawning striped bass was reported as 60º - 75º F (15.6°C-23.9°C) (Bell 1991). In the San Francisco Estuary spawning occurred at water temperatures of 57.2°F – 84.2°F (14.0º C - 29.0º C) (Hassler 1988).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Reported optimal water temperature range for striped bass spawning was 59°F -68°F (15º - 20º C) (Moyle 2002). Reported optimal water temperatures for spawning range from 62º - 67º F (16.7°C-19.4°C) (Bell 1991). In the San Francisco Estuary, striped bass spawning reportedly peaked at water temperatures of 60.8°F -68°F (16.0º C to 20.0º C) (Hassler 1988). In the Savannah River, spawning reportedly began at about 57.2°F (14°C) in March and ended in May after water temperatures exceeded 69.8°F (21°C) (Hill et al. 1989).	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.	Strong currents are needed for the development of striped bass eggs to keep the eggs off of the substrate, as observed in the San Francisco Bay area (Skinner 1962). A study conducted within the Delta found that striped bass were spawning in turbid water (visibility 15 inches) (Hassler 1988).	
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	The average water velocity was near 1 ft/s (0.3 m/s) during the spawning season in the Sacramento River (Stevens 1966). In the Sacramento Estuary, a minimum water velocity of	

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		0.98 ft/s (0.3 m/s) was reportedly needed to keep the stripped bass eggs suspended above the bottom of the estuary (previous laboratory experiments found that eggs allowed to rest on the bottom substrate did not hatch) (Hassler 1988).	
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.	Water depth range for spawning occurs from 10-75 feet (3.05-22.9 m), as observed in the San Joaquin River (Stevens 1966).	
water depth preference for spawning	Reported range of most frequently observed water depth utilization.	Large groups of striped bass reportedly gather at the water surface to spawn (Skinner 1962). Preferred spawning areas are reportedly shallow, ranging from 0.98-20 ft (0.3-6.1 m) (Hill et al. 1989). Striped bass spawning reportedly occurs close to the surface of the water (Moyle 2002).	
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	Striped bass spawning reportedly occurs from April through June (Bell 1991). Adults move into freshwater (into the Delta and upstream in the Sacramento River) to spawn in the spring (Hassler 1988). Spawning reportedly begins in April when striped bass, usually males first, start to move into suitable areas. The exact timing and location of spawning depends on the interaction of three factors: water temperature, flow, and salinity (Moyle 2002). Striped bass spawning reportedly occurs from April through June (Wang 1986).	
peak spawning timing	Time of year most fish start to spawn.	Striped bass spawning reportedly peaks in May or early June (Moyle 2002). In the Roanoke River, spawning reportedly peaked between May 10 and May 20 (Hill et al. 1989).	

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spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Striped bass are reportedly capable of spawning every year, given appropriate conditions (Moyle 2002). Striped bass are generally iteroparous, but mature females may not spawn every year (Emmett et al. 1991).	
Incubation/early development			
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Sufficient current is needed to suspend the fertilized eggs in the water column. Minimum water velocity is 1.02 ft/s (0.31 m/s). In California, eggs can reportedly survive at 0.6-2.9 ft/s (0.18-0.88 m/s) (SWRI 2002). Striped bass eggs are small and enlarge to 2x their size upon water hardening. Striped bass eggs are similar to those of shad, but reportedly can be distinguished by a large oil globule, which is not as apparent in shad eggs (Skinner 1962). Striped bass eggs are nearly transparent when developing and reportedly measure 0.13-0.17 inches (0.33-0.42 cm) in diameter (Emmett et al. 1991). Striped bass egg diameter reportedly ranges from 0.13 inches (3.2 mm) to 0.17 inches (4.3 mm). In California, mean egg diameter is 0.13 inches (3.3 mm), with size ranging from 0.13 - 0.17 inches (3.4-4.2 mm) (Wang 1986).	
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Water temperatures tolerated by striped bass eggs reportedly range from 53.6°F –71.6°F (12º - 22º C) (SWRI 2002). Striped bass eggs can reportedly withstand 53.6°F – 75.2°F (12º - 24º C), as observed within a variety of estuaries along the west coast (Emmett et al. 1991).	

Element	Element Descriptor	General	Feather River Specific
		In a habitat suitability index model, water temperatures for striped bass egg incubation were suggested to range from 57.2°F –73.4°F (14º C -23º C) (Hassler 1988). Striped bass larvae can tolerate water temperatures of 50°F-70°F (10º - 25º C) while the reported optimum temperature range for survival is 59°F –71.6°F (15º - 22º C), as observed within estuaries along the Pacific coast (Emmett et al. 1991).	
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Water temperatures suitable for striped bass egg incubation reportedly range from 60.8°F –66.2°F (16º - 19º C), as observed within a variety of estuaries along the west coast (Emmett et al. 1991). In a habitat suitability index model, water temperatures suitable for striped bass egg incubation were suggested to range from 62.6°F -68°F (17º C -20º C) (Hassler 1988).	
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.	Striped bass egg incubation reportedly requires 48 hours at 66.2°F (19º C) (Moyle 2002). Observations made along the west coast suggest that striped bass egg incubation takes 2 days at 60.8°F – 66.2°F (16º - 19º C) (Emmett et al. 1991). Striped bass egg incubation reportedly requires 2-3 days at 57.9°F – 69.8°F (14.4º - 21º C) (SWRI 2002). The time required for striped bass egg incubation reportedly ranges from 30 hours at 72º F (22.2°C) to 74 hours at 58º F (14.4°C) (Skinner 1962).	
size of newly hatched larvae	Average size of newly hatched larvae.	Newly hatched striped bass larvae reportedly range in size from 0.12-0.20 in (0.3-0.5 cm) (Skinner 1962). Data from the Pacific coast, at a variety of estuaries suggests that newly hatched striped bass larvae range from 0.08-0.15 in (0.2-0.37 cm) TL, and average 0.11-0.20 in (0.29-0.5 cm) TL (Emmett et al. 1991).	

Element	Element Descriptor	General	Feather River Specific
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.		
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Striped bass larval stages reportedly last approximately 4-5 weeks within the water column (SWRI 2002). The time required for absorption of the yolk sac in larval striped bass reportedly ranges from 3 days at 75.2°F (24º C) to 9 days at 53.6°F (12º C) (Emmett et al. 1991). Striped bass larvae develop suspended in water. If striped bass larvae encounter still water, they may settle to the bottom and die (Skinner 1962). Striped bass larvae school within 4-5 days of hatching (Emmett et al. 1991). The larval stage is perhaps the most critical stage in the striped bass life history as they are exposed to factors such as tides and predators (Skinner 1962). Larval growth and survival rates are reportedly highest in areas of brackish water, presumably because of reduced energy costs for osmoregulation (Moyle 2002).	
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.	Migration of striped bass larvae into the water column reportedly occurs from April to mid-June in the Sacramento River (Stevens 1966). Migration of striped bass larvae into the water column in the San Francisco Bay area reportedly occurs from mid- to late-July (Emmett et al. 1991).	
timing peak for emergence	Time of year most hatchlings emerge.	Migrations of striped bass larvae into the water column reportedly begin in July on the Hudson River (Hill et al. 1989). In the Sacramento River, larval striped bass migrations reportedly peak in the first part of June (Stevens 1966).	

Element	Element Descriptor	General	Feather River Specific
size at emergence from gravel	Average size of hatchlings at time of emergence.	In the Hudson River, migrations of striped bass larvae reportedly begin when larvae range from 0.28-0.55 in (0.7-0.14 cm) TL (Hill et al. 1989). Under laboratory conditions, striped bass larvae began feeding at 0.24 in (0.61 cm) TL (Hassler 1988).	
Juvenile rearing			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Survival of striped bass through the first year of life appears to depend, in part, on adequate river flows carrying them to suitable places for rearing. In California, Suisun Bay was believed to be an important rearing area for juvenile striped bass. However, this relationship has not been strong in recent years (Moyle 2002). The juvenile stage lasts from metamorphosis to sexual maturity. In the Pacific Southwest region, males 0.98-12.6 in (2.5-32.0 cm) FL and females 0.98-21.0 in (2.5-53.4 cm) FL are considered juveniles (Hassler 1988).	
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	In a habitat suitability index model, water temperatures for juvenile rearing were suggested to range from 50°F – 80.6°F (10º C -27º C) (Hassler 1988). In lab experiments, the reported upper avoidance water temperature of small individuals was 93.9°F (34.4° C) (Coutant 1977).	
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Water temperatures suitable for developing larvae and juveniles reportedly range from 55°F -75°F (12.8º - 23.9º C) (SWRI 2002). In a habitat suitability index model, preferred water temperatures for juveniles were suggested to range from 60.8°F –66.2°F (16º C -19º C) (Hassler 1988). The reported optimal water temperature for juveniles lies between 75.2°F and 78.8°F (24º C and 26º C), as determined through laboratory experiments (Hill et al. 1989).	

Element	Element Descriptor	General	Feather River Specific
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.	In a habitat suitability index model, water velocities for juvenile striped bass rearing were suggested to range from 0-16.4 ft/s (0-5 m/s) (Hassler 1988).	
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.	In a habitat suitability index model, preferred water velocities for juvenile striped bass rearing were suggested to range from 0-3.3. ft/s (0-1 m/s) (Hassler 1988). Juvenile striped bass were reportedly mostly concentrated in the shoal areas of the lower San Joaquin River. They may prefer these areas due to the lower water velocities (Stevens 1966).	
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.		
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.		
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	Juvenile striped bass reportedly prefer clean, sandy bottoms, but they have been found over gravel beaches, rock, mud, and mixed sand/silt bottoms within estuaries along the west coast (Emmett et al. 1991). Within Lake Texoma, striped bass juveniles reportedly prefer sandy shorelines in the autumn (Matthews et al. 1992). Juveniles studied in the Delaware and Hudson rivers were found to prefer clean sandy bottoms, but were also found over gravel beaches, rock bottoms, and soft mud (Hill et al. 1989).	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	Young-of-year striped bass juveniles [less than 3.9 inches (10 cm) FL] reportedly feed primarily on opossum shrimp, other planktonic crustaceans, and invertebrates, although amphipods, copepods and small threadfin shad may be important food items on occasion. Larger juveniles ranging from 10 - 13.8 inches (10-35 cm) FL	

Element	Element Descriptor	General	Feather River Specific
		have a diet similar to that of smaller juveniles, but fish become increasingly important in striped bass diets as striped bass increase in size. Sub-adult striped bass are piscivorous, though invertebrates can be important in winter and spring when fish are hard to find (Moyle 2002). In Lake Texoma, juvenile striped bass reportedly feed mostly on small fish and zooplankton (Matthews et al. 1992). Observations in the Sacramento River suggest that juveniles consumed sizable quantities of small Chinook salmon. Other major food items included northern anchovy, northern shiner, perch, striped bass, common carp, crayfish, bay shrimp, isopods, scuds, and insect larvae (Hassler 1988). Young striped bass reportedly entered their first fall feeding almost entirely on invertebrates. In their second summer, they reportedly began feeding primarily on young-of-the-year striped bass and threadfin shad, and as juveniles, they fed nearly half on fish and half on invertebrates (Stevens 1966).	
feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	Juvenile bass form small schools or feeding groups during the 1st and 2nd summers, as observed in the San Francisco Bay area (Skinner 1962). Striped bass are opportunistic feeders. Specific food types eaten depend on the size of the fish, the habitat, and the season. Juvenile striped bass reportedly begin to school while foraging (Hill et al. 1989).	
predation of juveniles	Indicate which species prey on juveniles.	Adult striped bass (Moyle 2002) and other piscivorous fishes are predators of juvenile striped bass. (Emmett et al. 1991). Adult striped bass are preyed on by humans and large marine mammals (e.g. seals and sea lions) (Emmett et	

Element	Element Descriptor	General	Feather River Specific
		al. 1991).	
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.	Young-of-the-year striped bass from the Hudson River began to move offshore in fall. In Virginia, a downstream migration of striped bass to higher salinities was reported during the first summer of life (Hill et al. 1989).	
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.	Growth of juvenile striped bass occurred primarily between May and November, as observed within the Sacramento-San Joaquin estuary. (Hassler 1988) In the spring, striped bass juveniles reportedly migrate toward the Delta. Female striped bass migrate to the Delta in late-spring and early- summer (Stevens 1966).	
Juvenile emigration			
time spent in fresh water prior to emigrating	Duration (in years and/or months) from emergence to emigration to the ocean.	The age at which striped bass juveniles start their first annual migrations between fresh and salt water has not been positively established on the West Coast. Most juvenile striped bass seem to undertake downstream migrations in the third year, though some may begin in the second year or wait until the fourth year (Skinner 1962). A literature review suggests that time spent in freshwater prior to emigrating varies, with some striped bass juveniles staying in fresh and brackish water, and many migrating to the ocean in the fall at 2 years of age (Bell 1991).	
water temperature tolerances during emigration	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Water temperature tolerance for juvenile striped bass reportedly ranges from 44.9°F – 80.6°F (7.2°-27°C) (Hassler 1988).	
water temperature preferences during emigration	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Laboratory studies report optimal water temperatures for striped bass juveniles lie between 75.2°F and 78.8°F (24° and 26°C). However, as striped bass age and grow, they reportedly undergo a shift in thermal preference towards cooler water temperatures (Hill et al. 1989).	
emigration timing range	Time of year juveniles commence emigration and	Striped bass emigration typically occurs in late-summer and fall (Bell 1991).	

Element	Element Descriptor	General	Feather River Specific
	duration of emigration.	Recovery of tagged fish suggested that striped bass move upstream into San Pablo Bay and Carquinez Strait in the fall, then into the Delta in the winter, spread out and ascend tributary rivers in the spring, and move down to the Bay again by early summer (Skinner 1962).	
emigration timing peak	Time of year most juveniles are emigrating.		
size range of juveniles during emigration	Minimum and maximum sizes (inches or mm) of emigrating juveniles. Indicate average size.	Striped bass taken from the Delta (in October) suggested that juveniles ranged in size from 2.9 to 4.0 inches (7.3 to 10.2 cm); the average size was approximately 3.5 inches (8.9 cm) (Skinner 1962).	
factors associated with emigration	Pulse flows, water temperature changes, turbidity levels, photoperiod, etc.		
Other potential factors			
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish.	Striped bass reportedly can withstand dissolved oxygen concentrations of 3-5 mg/L for short periods of time (Moyle 2002). 5 mg/L is the reported minimum recommended dissolved oxygen concentration for adequately maintaining the striped bass population (SWRI 2002). Dissolved oxygen concentrations of 2.0 mg/L have been blamed for the absence of striped bass eggs and larvae in portions of the Delaware River (SWRI 2002). In a habitat suitability index model, striped bass tolerance to dissolved oxygen concentrations ranged from 3-20 mg/L and the reported optimum dissolved oxygen concentration levels ranged from 6-12 mg/L (Hassler 1988).	
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.	Striped bass can tolerate pH ranging from 6-10, though rapid changes of 0.8-1.0 units may result in direct mortality to eggs and larvae (SWRI 2002).	

Element	Element Descriptor	General	Feather River Specific
		In a habitat suitability index model, tolerance to pH ranged from 6-10 and the reported optimum levels ranged from 7-9 (Hassler 1988).	
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Striped bass can reportedly withstand high turbidity, although extreme conditions inhibit reproduction (Moyle 2002). Stripped bass have been found to spawn in turbid streams (Hassler 1988). In a habitat suitability index model, turbidities above 500 mg/L were considered lethal to larvae and eggs (Hassler 1988).	
factors contributing to mortality	e.g. fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	Factors that have contributed to striped bass mortality include climatic factors, the south Delta pumps, other water diversions, pollutants, reduced estuarine productivity, invasions by alien species, and exploitation (Moyle 2002). Striped bass have reportedly been in decline since 1967 due to altered flow and water temperature regimes, fishing, entrainment in diversions, exposure to toxic materials, and habitat loss (SWRI 2002). In the 1980s, the abundance of striped bass in the Sacramento San Joaquin Estuary reportedly was 25% of what it was 20 years earlier. Several potential reasons for the decline are presented below (these reasons were determine through a literature review and summarization of previous studies conclusions) (Stevens et al. 1985): 1. the adult population, reduced by a combination of lower recruitment and higher mortality rates, produces fewer eggs; 2. production of food for young striped bass has been reduced; 3. large numbers of striped bass eggs and young are	

Element	Element Descriptor	General	Feather River Specific
		removed from the estuary by water diversion needed for agriculture, power plant cooling, and other uses; and 4. point and nonpoint discharges of pesticides and other petroleum products may cause mortality of adults, reduce their ability to reproduce, or reduce the survival of their eggs and young.	
Predation-related characteristics			
consumption rates by size	Rate of consumption of prey by predator size.		
consumption rates by lifestage	Rate of consumption of prey by predator lifestage.	Overwintering YOY striped bass in Hudson River consumed food at rates ranging from 0 – 0.29% body weight per day in lab conditions. Generally higher rates occurred early-winter than in late-winter. No significant patterns were observed in the laboratory studies conducted between individual gut fullness levels and water temperature, time of year, or body size (Hurst and Conover 2001).	
consumption rates by water temperature	Rate of consumption of prey by water temperature.	Overwintering YOY striped bass in Hudson River consumed food at rates ranging from 0 – 0.29% body weight per day in lab conditions at water temperatures designed to simulate winter water temperatures ranging from 35.6°F –51.8°F (2°C-11°C). Within this water temperature range, no positive relationship between consumption rate and water temperate was found. Generally higher consumption rates occur in early- winter than in late-winter (Hurst and Conover 2001).	
growth rate	Rate at which growth occurs.	Striped bass growth rate was most rapid during first 4 years, but the growth rate is highly variable depending on availability of food. In estuaries striped bass typically reach fork lengths of 3.5-4.3 in (9-11cm) in the first year, 9.1-11.8 in (23-30 cm) in the second year, 11-16.9 in (28-43 cm) in the third year, and 17.3-21.3 (44-54 cm) in the fourth year. After the fourth year, growth increments are approximately 1.9-3.9 in/yr (5-10 cm/yr) (Moyle 2002). Daily growth rates of young-of-the-year striped bass from	

Element	Element Descriptor	General	Feather River Specific
		the Sacramento-San Joaquin Estuary have been estimated at 0.02-0.04 in (0.05-0.1 cm) per day (Hassler 1988).	
community interactions (predators)	Known predators.	Silver hake (*Merluccius bilinearis*), striped bass (*Morone saxatilis*), and bluefish (*Pomatamus saltatrix*) are known predators of juvenile striped bass, whereas sea lamprey (*Petromyzon marinus*) may prey upon adult or juvenile striped bass.	
community interactions (prey)	Known prey.	Composite list of fish prey of striped bass in the Sacramento-San Joaquin Delta (Stevens 1966): American shad (*Alosa sapidissima*), Black crappie (*Pomoxis nigromaculatus*), Bluegill (*Lepomis macrochirus*), Carp (*Cyprinus carpio*), Chinook salmon (*Oncorhynchus tsawytscha*), Goldfish (*Carassius auratus*), Pacific herring (*Clupea pallasi*), Pond smelt (*Hypomesus transpacificus*), Sacramento blackfish (*Orthodon microlepidotus*), Sacramento hitch (*Lavinia exilicauda*), Starry Flounder (*Platichthys stellatus*), Striped bass (*Morone saxatilis*), Threadfin shad (*Dorosoma petenense*), Three-spined stickleback (*Gasterosteus aculeatus*), and White catfish (*Ictalurus catus*).	
community interactions (competitors)	Known competitors.		
predator diet by size	Diet of fish by size classes.	In Florida waters, the diet of striped bass ranging in total length from 2.0-6.0 in (5.1-15.2 cm) is dominated by mosquito fish (*Gambusia affinis*), mollies (*Mollienisia* spp.), and freshwater shrimp (*Palemonetes* spp.), whereas the diet of striped bass ranging in total length from 6.0-19 in (15.3-48.3 cm) bass was dominated by threadfin shad (*Dorosoma petenense*) (Hill et al. 1989). In Sacramento-San Joaquin Estuary, diet varies by size and season. For the young-of-year striped bass, mysid shrimp and amphipods are the most important component of the diet. As the fish grow, the diet shifts to forage fishes, primarily small striped bass and threadfin shad (Stevens 1966).	

Element	Element Descriptor	General	Feather River Specific
		Larval and juvenile striped bass are primarily invertebrate feeders. Larval and post-larval striped bass mainly feed on copepods. Historically larval and post-larval bass principally fed on *Eurytemora affinis* but after mid-1980s they fed on various alien species. YOY (less than 3.9 in [10 cm] FL) eat mainly opossum shrimps (*Neomysis mercedis)* and *Acanthomysis spp.*, amphipods, copepods, and occasionally small threadfin shad. Larger juveniles 3.9-13.8 in (10-35 cm) FL have a diet similar to YOY diet, with fish prey becoming increasingly important as bass increase in size. Subadults [age 2+, 10.2-18.5 in (26-47 cm) fork length] feed primarily piscivorously, but can prey on invertebrates in winter and spring when small fishes are hard to find. Adults in the Delta mostly feed on threadfin shad and smaller striped bass. In San Pablo Bay and Pacific Ocean, adults feed on a variety of pelagic species (anchovies and herrings) and on bay shrimp (*Crangon* spp.) (Moyle 2002). Additional information regarding the diet of striped bass by size class is available in Table 1 below.	
predator diet by age group	Diet of fish by age group.	Larval and juvenile striped bass are primarily invertebrate feeders. Larval and post-larval striped bass mainly feed on copepods. Historically larval and post-larval striped bass principally fed on *Eurytemora affinis* but after mid-1980s they fed on various alien species. YOY [less than 3.9 in (10 cm) fork length] eat mainly opossum shrimps (*Neomysis mercedis)* and *Acanthomysis spp.*, amphipods, copepods, and occasionally small threadfin shad. Larger juveniles [3.9-13.8 inches (10-35 cm)] FL have a diet similar to YOY diet, with fish prey becoming increasingly important as bass increase in size. Subadults [age 2+, 10.2-18.5 in (26-47 cm) FL] feed primarily piscivorously, but can prey on invertebrates in winter and spring when small fishes are hard to find. Adult striped bass in the Delta mostly feed on threadfin shad and smaller striped bass. In San Pablo Bay and	

Element	Element Descriptor	General	Feather River Specific
		Pacific Ocean, adults feed on a variety of pelagic species (e.g., anchovies and herrings) and on bay shrimp (*Crangon* spp.) (Moyle 2002). The diet of young-of-year striped bass consists mainly of planktonic and benthic organisms (Hassler 1988). In the Sacramento River, adult striped bass reportedly feed mainly on juvenile salmonids. In the American River, adult striped bass feed largely on crayfish and various native fish, while in Suisun Marsh, adults feed heavily on threespine sticklebacks coming out of marsh drains (Moyle 2002). In the Sacramento-San Joaquin Estuary, striped bass diet varies by size and season. For young-of-year striped bass, mysid shrimp and amphipods are reportedly the most important component. As the fish grow, the diet shifts to forage fishes, primarily small striped bass and threadfin shad (Stevens 1966). Additional information regarding diet of striped bass by age group is available in Table 1 below.	
association of predators to physical facilities including habitat conditions created by operations	Habitat conditions created by operations that are conducive to predation (velocities, temperatures).	Striped bass are reportedly a major source of mortality of juvenile salmon. Adult striped bass reside near screened diversions feeding on small fish, especially salmon, that concentrate near the diversions. Striped bass reportedly prey both on fish entering the fish rescue facility (in Clifton Court Forebay) and on fish that are trucked back to the Delta after being salvaged (Moyle 2002).	
association of predators to physical facilities including instream flow obstructions/diversions	Instream flow obstructions and/or diversions associated with structures and facilities that are conducive to predation.		
association of predators to physical facilities including unusual flow	Flow or water temperature associated with structures, or operations facilities that are		

Element	Element Descriptor	General	Feather River Specific
and/or water temperature patterns	conducive to predation.		

Table 1. Diet of striped bass by lifestage (and size) and season, based on stomach content analysis, in Sacramento River Source: (Stevens 1966).

Food Items	Young Bass 0+ -- < 1 yr old 5-12 cm -- 12-23 cm				Juvenile Bass 1+ -- 2 yrs old 13-25 -- 24-35 cm				Sub-adult Bass 2+ -- 3 yrs old 26-37 -- 36-47 cm				Adult Bass 3+ years old 38 cm -- >48 cm			
	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr	Sum
Annelids																
Unidentified			√													
Crustaceans																
Cladocerans and copepods			√													
Mysid shrimps (*Neomysis awatschensis*)	√*	√*	√*	√*	√*	√*	√*	√*		√	√*	√*	√	√	√	
Isopod (*Exosphaeroma oregonsis*)		√														
Amphipods (*Corophium*)	√*	√*	√*	√	√*	√*	√	√			√			√		
Crayfish (*Pacifastacus leniusculus*)			√						√		√*		√*			
Unidentified shrimp				√				√		√				√		√*
Insects																
Tendipedids	√	√	√		√			√								
Other insects		√		√		√										
Fishes																
Threadfin shad (*Dorosoma petenense*)					√		√					√*		√*		
American shad (*Alosa sapidissima*)			√	√				√	√*	√*				√*		
Chinook salmon (*O. tshawytscha*)							√	√								√*
Pond smelt (*Hypomesus transpacificus*)				√			√	√*	√		√*			√	√*	
Striped bass (*Morone saxatilis*)				√*	√*			√*	√*	√*	√*	√*	√*	√*	√*	√*
Unidentified fishes				√	√	√	√	√	√*			√		√	√*	√*
Sardine and anchovy bait		√			√	√*	√*		√*	√*	√		√*	√		

*indicates major diet component

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